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WHO BENEFITS FROM BIOMED?

Real Jobs for Boston Residents

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Who Benefits from Biomed?
Real Jobs for Boston Residents
REPORT HIGHLIGHTS

- 20,000 new Metro Boston jobs in the biomedical industry will be created by 1995.
  - 7,330 will require a Master's degree or above.
  - 7,740 will require a Bachelor's degree.
  - 4,927 will require less than a bachelor's degree.
  - Wages for non-college jobs range from $7 - 15 per hour.
- 13,000 new jobs will be in the private biomedical industry.
- 7,000 new jobs will be in Boston Academic Medical Research institutions.
- Less than 1% of Boston Public School graduates entered health professions from 1978 - 1990.
- Gaps in the education and training system indicate inadequate skills training to meet the employment needs of the industry.
- The City of Boston, private firms, research institutions, and education/training system must collaborate to sustain growth, capture long-term benefits, and create training opportunities.

KEY RECOMMENDATIONS:

- Target city's property resources and financing tools to attract and retain biomed. companies.
- Work closely with the Massachusetts Congressional delegation to maximize Federal research funding opportunities.
- Establish a Center of Excellence for Biomedical Research: incubator space for startup firms, technical assistance, venture capital, and shared services for "adolescent" firms.
- Form a Boston Biomedical Industry Association, a partnership of public, private, and institutional players.
- Develop appropriate investment incentives and a legislative agenda to capture long-term growth benefits.
- Develop and support a full range of industry-specific training programs, including a Boston Academy for Vocational and Applied Technology.

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REAL JOBS FOR BOSTON RESIDENTS

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WHO BENEFITS FROM BIOMED?
REAL JOBS FOR BOSTON RESIDENTS

EXECUTIVE SUMMARY

The recently issued report by the Howell Group for the Boston Redevelopment Authority presents an excellent case for Boston's unique prospects for long-term economic growth. The Boston-Cambridge "intellectual infrastructure," particularly the presence of many of the world's finest educational and medical research institutions, is cited as a key factor in Boston's locational advantage in the new "knowledge-based", innovation-driven economy. Howell draws from Michael Porter's work on competitiveness, which lays a conceptual foundation for "clusters" of geographically concentrated industries which comprise a self-reinforcing system. In Boston, this system includes both private and institutional biomedical research competitors, as well as suppliers, customers, and related industries, such as biotechnology and medical instruments. Boston's innovative industries have access to a steady stream of highly educated, specialized workers, whose sophistication and entrepreneurial ability is complemented by high quality business and financial services which finance and serve growing ventures.

The city's thriving intellectual life is enhanced by its attractive urban environment, cultural amenities, and the diversity of its residential neighborhoods. Equally important, the Flynn administration has delivered high-quality public services while demonstrating sound fiscal management, exemplified by six years of balanced budgets and five bond rating upgrades in five years.

Boston's economic development agency, EDIC/Boston, has completed a survey to examine job creation potential of Boston's private biomedical industry growth and Boston's burgeoning medical institutions' research activity. **According to our projections, 20,000 new jobs will be created in the Metro Boston biomedical industry between now and 1995.** The survey, conducted with the chief executive officers and human resource directors of over 100 metropolitan Boston private firms and major Boston teaching hospitals, identifies "targets of opportunity" for meaningful employment for residents of Boston's neighborhoods. In order to help Boston capture this growth, the survey also contains an analysis of firms' and institutions' space needs, as well as factors which influence their locational decisions. Finally, the EDIC/Boston survey analyzes the current capacity of the local education and skills training system to meet the labor force needs of this fast-growing sector.

During the past six months, a general economic slowdown has led to an expansion of available industrial and commercial space in Boston. The demand for quality industrial space, particularly for Research and Development, however, remains high. Our research indicates that demand for both quality R&D space and manufacturing space for biomedical industry firms will **increase** over the next 2-5 years. **A key element in Boston's ability to capture local benefits of this projected growth will be the recruitment and retention of businesses which are expanding, particularly of those which are moving toward product development and manufacturing where job opportunities at all levels may be captured by Boston residents.**

Despite Boston's well-deserved reputation as a "medical mecca" and world-class academic center, many of Boston's residents have not shared in the economic growth and quality of life benefits of the presence of the city's fine institutions. The historical problems of the Boston Public School system are well-documented and will not be rehashed in this report. According to annual exit surveys conducted by Boston Public Schools Office of Student Services, **less than one percent of Boston public high school graduates have entered into health professions** training annually since 1978. As demand for a highly-skilled and well-educated workforce in the knowledge-based industries continues to grow and as these industries provide the most optimistic growth prospects in the nineties, there remains a critical imperative to adjust the City's education and skills training system to assure that Boston residents are prepared to obtain good jobs in these growth industries.

The relationship of educational attainment to economic success is well-documented. Clearly, Boston must create and nurture a system which guarantees at least a high school diploma or its equivalent to any person who wants one. Moreover, Boston's institutions, both public and private, must cooperate to adapt to support the changes in education and training which are necessary for renewed prosperity for the region and its citizens. The challenge is for the private companies, major research institutions, government, and public and higher education to forge a common agenda which merges the goals of social justice and prosperity. **This report acknowledges the leading role biomedical research will have in Boston's and the region's economic prosperity in the nineties. It will also identify employment opportunities in this growth industry for those Boston residents who have historically been denied access to the benefits of growth in other sectors, notably high technology and health services.**

According to EDIC's recently-conducted survey of private biomedical companies in Metro Boston, 32% of the jobs in the for-profit biomedical industry require at least a Master's degree. The trends further indicate that 43% of the remaining 68% of the jobs in the industry are filled by persons with a four-year college degree while 25% of the jobs require either a high school education or some skills equivalency. Although our survey and other literature on the biomedical industry cannot quantify future trends on educational preparation of the industry's workforce, it is safe to project that as the private biomedical

industry moves towards commercialization in the nineties, greater opportunities for those with some college education or less will be created.

Currently, Boston's teaching hospitals and research institutions employ 7869 people in their research operations; 45% of the jobs in institutional research require an advanced degree. Of the remaining positions, 31% require a four-year degree while 24% require less than a four-year degree.

EDIC/Boston projects, by 1995, 7,330 new Metro Boston biomedical research and manufacturing jobs for which a Master's degree or above will be the entry-level requirement. By 1995, we project **7,740 new Metro Boston biomedical industry jobs for which a bachelor's degree will be the entry-level requirement.** The report also identifies those **research-specific** job categories in both private biomedical firms and institutional medical research, for which a four-year post-secondary degree is **not** a requirement. We project, by 1995, **4,927 new research-specific jobs in this category.** In identifying this level of job creation and growth, we will measure actual points of entry, and career mobility, for Boston residents seeking career opportunities. We also include in our conclusions a set of policy recommendations which emphasize the critical need to insure that all of Boston's citizens have opportunity and access to the benefits of the knowledge-based city.

Survey Methodology

The survey has three objectives:

1.) To measure job creation potential of Metro Boston's private biomedical industry and of Boston teaching hospitals' medical research activity.

2.) To identify specific "targets of opportunity" in the biomedical and medical Research industries for residents of Boston's neighborhoods.

3.) To analyze the current capacity and identify gaps in the biomedical and medical research-oriented education and job training system.

Survey Population

The survey population was drawn from 135 Metro Boston Biomedical firms. The biomedical firms comprising our survey population include biotechnology, medical manufacturing, and pharmaceutical companies. Firms ranged in size from small (1-20 employees) and medium-sized (21-100 employees) firms to larger (101-1,000 employees) firms with R&D and manufacturing operations. We received a response from over 40% of the private firms surveyed. All responding firms are located in Boston, Cambridge, or within Route 128.

The response from Boston's teaching hospitals represents 30% of the top Boston recipients of National Institutes of Health (NIH) research dollars. The institutional respondents also include four of the five top Boston recipients of NIH funding (1988 awards), and five of the fastest growing research institutions in the region (Boston has recently surpassed New York as the city receiving the largest allocation of NIH funding in the US).

Included among the survey are teaching hospitals of Harvard University, Boston University, and Tufts University Schools of Medicine. All of the institutions surveyed have just completed, or are anticipating completing, large-scale real estate development projects designed to further their research goals.

(see Appendix, Boston Area Research Institutions)

Table 1: EDUCATIONAL PREPARATION FOR BIOMEDICAL EMPLOYMENT IN METRO BOSTON'S PRIVATE BIOMEDICAL INDUSTRY AND BOSTON'S MEDICAL RESEARCH INSTITUTIONS,

	MEDICAL INSTITUTIONS (RESEARCH EMPLOYMENT) BOSTON	PRIVATE BIOMEDICAL INDUSTRY METRO BOSTON	EMPLOYMENT GRAND TOTAL
1990			
TOTAL JOBS	7,869	17,585	25,454
Master's Level or More	3,541	5,627	9,168
4-Year College Degree	2,439	7,562	10,001
High School/Skills Equivalency	1,889	4,396	6,285
1995			
TOTAL JOBS	15,029	30,422	45,451
Master's Level or More	6,763	9,735	16,498
4-Year College Degree	4,659	13,081	17,740
High School/Skills Equivalency	3,607	7,606	11,213
1990-1995			
TOTAL NUMBER OF NEW JOBS	7,160	12,837	19,997
% Employment Growth	91%	73%	79%
Master's Level or More	3,222	4,108	7,330
% To Total Number of New Jobs	45%	32%	37%
4-Year College Degree	2,220	5,520	7,740
% To Total Number of New Jobs	31%	43%	39%
High School/Skills Equivalency	1,718	3,209	4,927
% To Total Number of New Jobs	24%	25%	24%

Source: EDIC/Boston, Private Biomed. and Medical Institutions Surveys, 1990
File: BIOEDUC1.wk

Career Opportunities for Boston Residents

One of the key characteristics of the knowledge-based city is a highly skilled, specialized labor force with many engineers, scientists, managers, and other professionals. The Metro Boston area, home to over 65 colleges and universities, obviously provides a critical mass of the necessary labor force to drive the innovative types of industries in our survey. Over 160,000 students attend colleges and universities in Boston and Cambridge alone; nearly 30,000 students receive a Bachelor's or advanced degree every year from Boston and Cambridge institutions. Over 70% of the students enrolled come from outside of Massachusetts, including students from 100 different countries. This high-quality academic environment creates healthy competition among both private firms and medical institutions for employees at all levels of the biomedical industry, from world-class researchers (mostly M.D. or Ph.D.) level to entry-level technicians and assistants.

The availability of qualified workers gives Boston an unrivalled national competititive advantage. EDIC/Boston, through its Jobs and Community Services Department, operates the city's job training and employment services system; we are particularly interested in examining points of entry into medical research and manufacturing jobs, and issues affecting employees' career mobility. **A particular challenge for Boston's government, institutions, private companies, and higher education, is to create a vocational/technical education and training system which provides access at all levels, from secondary school to advanced degree training, for all of Boston's residents.**

Institutions: International Leaders in Research

Boston's academic medical institutions play a pivotal role as the driving force for biomedical industries. The research which is prompted by clinical problems presented by patients often leads to the development of medical inventions or biomedical agents. The use of chemotherapy to treat cancer, the use of the laser as a scalpel in surgery, the growth of new blood vessels and artificial skin for burn victims -- all have spawned the development of commercial products and "spin-off" biomedical private companies.

Boston is home to three world-class medical schools (Harvard, Boston University, and Tufts), and their sixteen teaching hospital affiliates. Three Schools of Dentistry and five major non-profit medical research institutions are located in the city. Boston receives the highest amount of NIH research funding of any city in the United States. Over 50,000 people are employed in Boston's medical industry, making it the largest employer sector in the city. Nearly 12% of all people employed in Boston work in the medical/health care industry.

Nearly 8,000 people are employed in research positions in Boston teaching hospitals and non-profit research institutions. **Boston' institutions will create 7,160 new jobs in research by 1995; by 1995, Boston institutions will employ about 15,000 people in their research operations.**

EDIC/Boston's survey of Boston's medical institutions' research activity indicates that 3,222, (or 45%) of the 7,160 **new** research-related jobs which are projected to be created by 1995 will require a Master's degree or more. An additional 2,220 projected new jobs will benefit those with a college degree. By 1995, there will be 1,718 new institutional jobs which will not require a college degree.

As in the private biomedical research industry, it is essential that Boston continue to attract, retain, and train the elite category of biomedical research personnel for which it is renowned. The New England Board of Higher Education, the Massachusetts Centers for Excellence, the Mass. Biotechnology Council, and the Massachusetts Higher Education Task Force on Biotechnology have all made excellent recommendations in recent reports. A primary focus of the recommendations is the need for education and training programs **at all levels**, from post-doctoral research fellowships to public school math and science curriculum enhancement. The continuous investment in specialized recruitment, education, and training is essential to Boston's retaining its competitive advantage. We cannot afford to repeat the recent process in New York City, whose leadership position in the attraction of Federal research dollars was lost, mainly due to a failure to attract and retain a pool of the nation's brightest young researchers.

Private Biomedical Companies: Opportunities in All Levels

Total employment among private Metro Boston biomedical companies is projected to increase by 27% by 1992 and by 73% by 1995. These projections are based upon only existing companies, and do not factor in potential job growth from new start-up firms or firms which relocate to Boston from other areas. Currently, there are **17,585 total jobs in the private biomedical industry** in Metro Boston. **By 1992, the industry will create 4,748 new jobs in Metro Boston. By 1995, 12,837 new jobs will be created by the industry in Metro Boston.**

Employment in the research component of biomedical companies is expected to grow by 34% by 1992 and by 79% in the next 5 years. Private biomedical companies expect their manufacturing activities to accelerate in two years -- the firms project a 50% increase in manufacturing employment by 1992 and a 154% increase in the next 5 years. Since the timeline for product development, which triggers manufacturing operations, varies according to the pace and type of research, the phase-in of manufacturing operations must be closely tracked.

Personnel needs change with the maturation of the industry. Typically, early R&D stages require more highly-trained (Master's and Ph.D. level) researchers and supporting technicians. As potential commercial products are developed, a variety of engineering, biological and clinical specialists, and regulatory affairs experts are required. Finally, at the stage of product manufacturing, technicians and quality control specialists are needed at a variety of levels; marketing and business specialists are also required as products are introduced. **The general trend is toward a gradual decline in the proportion of Ph.D level researchers as companies mature.** Boston can and must continue to attract and retain world-class researchers to stimulate the growth of the biomedical industry. The ground-breaking research and development work, enhanced by the funding these "cutting-edge" researchers will attract, is essential in catalyzing the growth of the industry.

EDIC's survey of Metro Boston biomedical companies indicate that there will be 4,108 new jobs for which a Master's degree or higher will be required. An additional 5,520 new jobs for which a college degree will be required will be created in Metro Boston biomedical companies by 1995.

Based upon our projections, the private **biomedical firms in Metro Boston will experience a 73% growth between 1990 and 1995 in jobs which require less than a college degree, for a total of 3,209 new jobs which will require a high school diploma or GED**.

Specific Points of Entry

The EDIC/Boston analysis includes a focus on job creation and growth at the points of entry into both the private biomedical industry and the institutional medical research employment. The EDIC surveys identified 19 specific job categories in both the Metro Boston private biomedical industry and Boston medical institutions' research activities which do not require a college degree. These job categories represent specific points of entry into the biomedical industry, and are a sample of the private companies' and institutions' employment for which a college degree is not necessary.

There are fourteen specific non-degreed research job categories which represent points of entry into Boston's institutional medical industry's research activities, and five identifiable points of entry into the private biomedical industry. These specific positions are projected to create 826 new non-degreed jobs by 1995 (552 by the medical institutions' research activities and 274 by the private biomedical industry). This level of job creation represents 17% of the 4,927 total new non-degreed jobs which are projected to be created between 1990 and 1995.

The wages for the medical institutions' fourteen specific non-degreed job categories range from $6.96 - 16.71 per hour, or $14,560 - 33,280 per year. The mean wage for the fourteen positions is $9.89 per hour, or an **annual salary of $20,571.** Note: All teaching hospitals offer liberal fringe benefits, including full health insurance coverage, to employees working 20 hours or more per week.

A sample of non-degreed job categories and their existing and potential employment levels are presented in the following page.

Table 2: SAMPLE OF NON-DEGREED RESEARCH JOB CATEGORIES

A. MEDICAL RESEARCH INSTITUTIONS IN BOSTON

JOB CATEGORY	1990 # JOBS	1995 # JOBS	1990-1995 # NEW JOBS	HOURLY SALARY RANGE (1990 LEVELS)
Lab. Technician	20	26	6	$13.00
Clerk Phlebotomist	34	64	30	$ 9.20 - 10.00
Non Invasive Technician	6	16	10	$ 8.20
Arrethemia Assistant Tech.	6	14	8	
Radiographic/Diagnostic	80	172	92	$13.10
Research Aid/Secretary	40	100	60	$ 8.18 - 11.79
Darkroom Technician	14	34	20	$ 7.44 - 9.91
Veterinary Assistant	2	4	2	$ 9.20
Drug Prep. Technician	30	60	30	$ 8.21
Pharmaceutical Technician	198	228	30	$ 7.42 - 8.65
Animal Technician	92	156	64	$ 7.05 - 8.97
Lab. Assistant	64	146	82	$ 7.25 - 9.47
Glass Washer/Lab. Assistant	58	106	48	$ 6.60 - 8.63
Glass Washer	68	138	70	$ 6.96 - 8.28
SAMPLE TOTAL	712	1264	552	

B. PRIVATE BIOMEDICAL INDUSTRY IN METRO BOSTON

JOB CATEGORY	1990 # JOBS	1995 # JOBS	1990-1995 # NEW JOBS	ANNUAL SALARY RANGE (1990 LEVELS)
Technician	516	717	201	$15,000 - 19,000
Lab. Assistant	18	54	36	$16,161 - 20,020
Lab. Aide	4	9	5	$15,000
Assembler	224	247	23	$11,830
CAD/CAM	4	13	9	$25,000
SAMPLE TOTAL	766	1040	274	

Source: EDIC/Boston, Private Biomed. and Medical Institutions Surveys, 1990.
File: NONDEGRE.wk1

Future Growth

Institutions

Over the past five years, Boston's medical research institutions have added over 3 million square feet of new research, educational, clinical, and administrative space. The six institutions in our sample project research expansion space demand of 1,894,000 sf by 1997. Boston's medical research institutions project expansion space for research alone of over 3.3 million square feet by 1999. Most of the demand for this space will be in four areas: Longwood Medical Area, Charlestown Navy Yard, South Cove/South Station, and Crosstown.

It is imperative, if Boston is to continue to benefit from the growth of biomedical research, that institutional research development projects proceed with the full support of both government and financial institutions.

Private Companies

Metro Boston's private biomedical companies report that they consider the following factors in their locational decisions:

Rent and lease terms -- most important
Transportation access and Ability to expand/reorganize -- important
Availability of labor -- slightly important

Sixty-six percent of Metro Boston's private biomedical companies are planning to expand or consolidate their research and manufacturing operations on site; 20% plan to expand elsewhere in Metro Boston; and 13% plan to expand elsewhere outside Metro Boston.

Eighty-six percent of private biomedical companies will likely remain at their current location. Fourteen percent plan to relocate.

Nearly all companies who are already at the manufacturing stage have their manufacturing and R&D operations located in the same building. The industry generally prefers to have their manufacturing operation close to or at the same location as R&D operation.

The challenge for Boston is to develop a strategy to both retain and recruit expanding companies, particularly those who are at or near the manufacturing stage, where job growth is potentially greatest.

Education, Job Training, and Career Mobility

Institutions

All of the surveyed institutions provide a range of educational, informational, and training programs to their employees. In addition to their teaching affiliations with schools of medicine, most of the institutions have some formal and/or informal relationships with community-based training programs, Boston and other local public schools, or a local community college. An estimated $2.5 million was spent in 1989 by Boston's academic medical research institutions on education and training programs for area residents.

Respondents to the survey **unanimously reported that the local job training/educational system does not offer appropriate skills training to meet the labor needs of their growing research activities.**

One strategy adopted by some institutional respondents in our survey is to recruit "over-qualified" candidates, i.e., college graduates, for positions which, in other institutions surveyed, do not require a college degree. The steady stream of Metro Boston university and college graduates (25,000 per year) creates a readily accessible pool from which to draw entry-level research personnel. Boston institutions invest heavily in newspaper and professional journal personnel advertising; annual budgets for "help wanted" ads range from $150,000 - $ 1,000,000 among Boston's research institutions. Overall, Boston's research institutions spend nearly $6 Million annually on classified advertisements for personnel.

Institutions' Human Resource Directors identified the following impediments to career mobility and/or access to research-related careers:

- Insufficient skills---particularly math/science skills.
- Poor interpersonal, "job-readiness" skills.
- Lack of relevant research-related experience.
- Poor literacy skills.
- Educational attainment----lack of high school diploma/GED.

Over 40% of Boston ninth graders currently do not graduate from high school. Of the remaining 60% who attain a high school diploma, over half will not move into post-secondary education. Of those who do matriculate in post-secondary education, only 20% will graduate and attain a bachelor's degree. In 1990, a Boston public school student has a less than one-in-fifteen chance of graduating from a four-year college. These are the current statistical realities of a public educational system which serves those students in greatest need of a quality education which provides them with the resources and skills necessary to compete in an increasingly technical society and labor

market.

For many of Boston's residents, particularly those who have left school or are recent immigrants to our city, the obstacles to a college education are many. It is from these two groups that EDIC/Boston, through its Jobs and Community Services Department, draws a high proportion of its clients. A recent study of Boston's low income neighborhoods by Northeastern's Center for Labor Market Studies and the Community Jobs Collaborative cited a response from 83% of those residents surveyed that "the inability to obtain full time, decent paying jobs was a very important problem in their neighborhoods." Hispanics and Blacks, those lacking a diploma, the unemployed, and the working poor in particular were much more likely than their counterparts to feel pessimistic about their future prospects with regard to good jobs.

Private Companies

Over 50% of Metro Boston's private biomedical companies do not provide any educational, informational and training programs for their employees. All companies surveyed reported that the local job training/educational system does not offer appropriate skills training to meet their specialized labor needs. In particular, companies cited lack of familiarity with the research environment and poor math and science skills as common deficiencies of applicants for entry-level research positions.

Maximizing the local benefits of commercialization of biomedical research is not guaranteed. Western Europe and Japan have demonstrated that they are prepared to vigorously pursue later-stage biomedical industry operations, particularly manufacturing, through creating conditions favorable to the commercialization of early-stage research conducted in the United States. These conditions include less regulation and fewer legal restrictions, long-term capital financing, and tax incentives. Equally important, European and Japanese firms' commitment to employee training programs and access to a trained labor force via their high-quality public education systems will increase the competition for capturing long-term benefits of the industry.

Impediments to career mobility from lower-end jobs to technical and higher paying jobs, as cited by Metro Boston biomedical firm officials, are ranked below:

- Insufficient skills, training -- most significant impediment
- Poor interpersonal skills, lack of work experience -- significant impediment
- Educational attainment -- slightly significant impediment

Educational and Training Capacity: Closing the Gap

EDIC completed a separate survey component which included 100 Greater Boston community-based training programs, public schools, public and private 2-year colleges, public and private 4-year colleges, and graduate schools. Eighty-four percent of the respondents are located in Boston. Half of the student population of the respondent institutions are Boston residents.

Of the institutions surveyed, **only four offered education and training programs specifically designed to prepare students for jobs in medical research. The average annual capacity in these four programs is twenty-five students**. The replication and proliferation of excellent pilot programs initiated by the Bay State Skills Corporation, community colleges, Boston University, and other national and international models, is a critical element in the development of the biomedical industry.

Community-based training programs tended to focus on Literacy, English-as-a-Second Language (ESL), and high school equivalency (GED) programs. Most employment skills programs surveyed offer programs designed to prepare unemployed individuals for entry-level, non-research jobs. These programs generally concentrate on "job-readiness" skills, such as career exploration, job awareness, interviewing skills, and resume writing. Nearly all of the programs surveyed do **not** offer training which is career-specific.

Most educational and training institutions screen their applicants through some means of standardized testing. Nearly all offer academic counseling, tutoring services, career counseling and job placement as part of their programs. Financial aid counseling and scholarship programs are also widely reported services offered by education and training programs. Half of the training institutions utilize a permanent job placement officer. Two of the institutions surveyed, both of which are health-related "specialty" training organizations, place over 80% of their graduates in jobs in the health care industry.

Respondents were asked to cite the factors most important in preparing their students/trainees for well-paying, high-demand jobs in the medical research industry. The most widely cited factors are:

- Increasing language (literacy and speaking) skills
- Intensive, career-specific skills training
- Close cooperation with medical industry staff
- Mentoring by medical professionals

Respondents were asked also to recommend strategies to provide greater access for students/trainees to well-paying, high-demand jobs in the medical research industry. The most widely cited recommendations are:

- The establishment of industry partnerships and collaboratives.
- Development of collaborative criteria with industry to establish competency-based curricula.
- Development of "articulated" programs and career ladders.
- Promote greater sensitivity among employers to social, economic, and cultural issues affecting students/trainees.
- Provide more funding mechanisms for industry/education/training collaboratives.

Recommendations

- Nine private biomedical companies currently located in Metro Boston will be **targeted as potential tenants** for the City of Boston as they expand their operations. They would be the source of over 500 and 650 projected new biotech jobs for the City in 1992 and 1995, respectively. These companies expect to contribute some 172 new research jobs and 216 new manufacturing jobs in 1992, and over 200 new research and 345 new manufacturing jobs in 1995.

- The City of Boston will **target property resources**, including the EDIC's Marine Industrial Park and Crosstown Industrial Park, and Olmsted Plaza, Parcel 18, and South Station/Technopolis. EDIC will utilize its **financing tools** (BIDFA, BLDC) to assist new and growing biomedical companies, as well as to companies which we hope to attract from outside the region.

- Boston's teaching hospitals, medical schools, and research institutions should **work closely with the Massachusetts Congressional delegation** to insure that Boston at least retains its share of Federal research grant funding. The recent experience of the MIT Bitters Laboratory, as well as a change in leadership at the NIH, should be a signal that the competitive stakes for research dollars have been raised.

- The City of Boston should, along with the Commonwealth and the Higher Education institutions, establish a **Center of Excellence for Biomedical Research and Development**; the Center could include incubator space for startup firms, technical assistance, a public/private venture capital fund, and a vial-filling facility for maturing pharmaceutical firms.

- The City of Boston will convene a **regional conference of the biomedical industry** to develop a shared legislative agenda, a program of appropriate investment incentives, and a set of incentives to capture the long-term benefits of biomedical manufacturing in the region.

- The City of Boston should form a **Boston Biomedical Industry Association**, comprised of public, institutional, and private representatives. The Association's first priority should be the development of education and training programs for the biomedical industry. Among the programs recommended are:

    - Boston's **Academy for Vocational and Applied Technology** to train future workers in the biomedical industry. The Academy would be a locus of education and training which would also include a **teacher training** center, and a retraining center for workers in need of an orientation to emerging technologies.

- A **competency-based curriculum and apprenticeship programs**, coordinated among public schools, community colleges, universities, and private companies/institutions which prepare workers for entry-level positions with a **continuum of upgrading at the workplace.**

- **Targetting of linkage funds** through the Jobs Trust for **school-to-work transition** programs and workplace education.

- The Commonwealth and the city should catalyze, through **incentives and legislation**, the proliferation of employee education and career ladder programs, public school/industry partnerships, tuition reimbursement programs, loan forgiveness and scholarship programs. An example from Europe and Japan is the use of **skills incentive taxes** derived from a small percentage of companies' annual payrolls, and applied toward workers' upgrading.

- The Commonwealth should replicate the **Bay State Skills 50-50 match** program in biotechnology, which promotes industry/higher education partnerships in developing state-of-the-art curriculum and industry specific training programs. Pilot and fund **evening and weekend certificate and Associate degree programs** in biomedical research.

Appendix: Boston Area Research Institutions
Research Grants from National Institutes of Health
FY 85 and FY88

Institution	FY 85	FY 88	% GROWTH FY 85-FY 88
Harvard Medical School	56,700,000	66,867,643	18%
Massachusetts Institute of Technology	42,300,000	49,739,907	18%
Brigham & Women's Hospital	33,800,000	50,615,769	50%
Boston University School of Medicine	31,900,000	37,678,232	18%
Massachusetts General Hospital	29,200,000	42,906,200	47%
Dana-Farber Cancer Institute	25,300,000	36,777,833	45%
Children's Hospital	18,800,000	21,469,930	14%
Tufts University School of Medicine	17,900,000	19,177,169	7%
Harvard University	12,900,000	18,435,290	43%
Beth Israel Hospital	9,600,000	11,770,419	23%
New England Medical Center	8,800,000	17,777,078	102%
Eye Research Institute--Retina Foundation	5,300,000	5,954,634	12%
Whitehead Institute for Biomedical Research	5,100,000	7,663,298	50%
Massachusetts Eye & Ear Infirmary	4,900,000	6,589,899	34%
Forsyth Dental Center	4,900,000	4,866,923	1%
Center for Blood Research	3,500,000	5,528,291	58%
Joslin Diabetes Clinic	3,500,000	4,722,800	35%
Boston City Hospital	3,100,000	3,803,991	23%
New England Deaconess Hospital	2,700,000	6,350,864	135%
University Hospital	2,700,000	4,640,217	72%

Source: NIH Research Grant Directory, 1985
NIH Grants & Awards, "Research Grants, FY 88 Funds" (microfiche AS14434-7, Boston Public Library Government Documents room)